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ABSTRACT

Technologies can play a role in restructuring schools, but they can also effectively support existing school structures depending on how they are designed and used. This paper contrasts the organizational impact of two technology systems in terms of the physical location in the school, the curriculum, how time is scheduled, and the opportunities afforded students to engage in long-term, open-ended projects. Considered first are integrated learning systems, a class of computer systems designed to fit in well with existing school organizations. In contrast, an environment called Earth Lab is described, and its application in the restructuring of a school is illustrated. The Earth Lab project has been designing, implementing, and observing the effects of a local area network (LAN) system intended to facilitate collaborative work in elementary school earth science instruction. It is noted that the flexibility of location and time, the collaboratively constructed interdisciplinary curriculum, and the provision for student access to the tools, are critical components of this environment. A discussion of the complex relationship between school restructuring and the implementation of technology for schools concludes the report. (14 references) (Author/DB)

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Technology as Support for School Structure and School Restructuring

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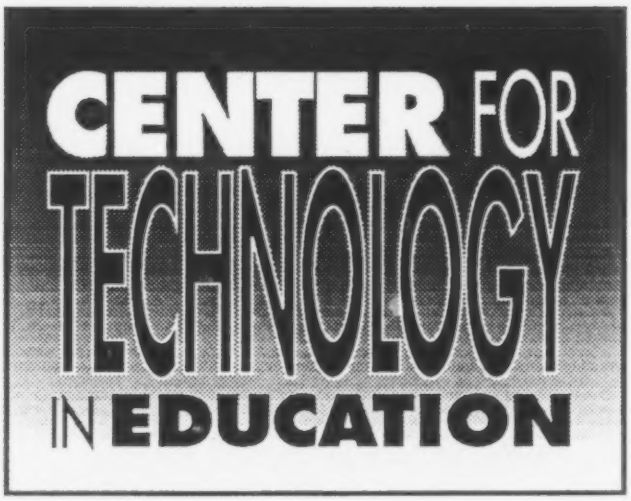

Technical Report No. 14

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TECHNOLOGY AS SUPPORT FOR SCHOOL STRUCTURE AND SCHOOL RESTRUCTURING

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Technologies can play a role in restructuring schools, but they can also effectively support existing school structures depending on how they are designed and used. This paper contrasts the organizational impact of two technology systems in terms of the physical location in the school, the curriculum, and how time is scheduled. Considered first is a class of computer systems designed to fit in well with existing school organizations. In contrast, an environment called Earth Lab is described, and its application in the restructuring of a school is illustrated. In conclusion, the complex relationship between school restructuring and the implementation of technology for schools are addressed.

School restructuring is currently a focus of many school reform efforts that recognize that improving education requires changes in governance, modes of teacher-student interaction, incentives, and methods of evaluation (Carnegie Forum on Education and the Economy, 1986; Sizer, 1984). Technology's roles in schools and school restructuring is very much a matter of debate. While it has been common for technologists to paint scenarios in which schools are transformed by technology, other analysts of school change argue that technology will not penetrate beyond the margins of the school system (Cohen, 1988; Cuban, 1986). Collins (in press) argues, on the other hand, that the rapidly growing role of technology in the workplace will drive the adoption of technology in schools and spur collateral changes, including a shift from lecture to coaching and from a competitive to a cooperative social structure. Both positions assume an incompatibility of technology and current practices, an assumption that oversimplifies the potential impact of the adoption of technology. Much of the widespread implementation of computer technologies in schools is, in fact, quite compatible with existing structures. To support restructuring, technologies must be specifically molded to the task.

This paper describes a technology environment called Earth Lab, which is intended to support a fundamental change in the school away from the typically isolated classrooms, compartmentalized curriculum, and constraints of class schedules. The paper begins with a contrasting case, a class of computer systems designed to fit into the existing school structure. The technology design itself does not determine an impact on the school. The contrast is largely in the way the technologies are typically put to use. The systems are also contrasts in market success—in one case, there is a rapidly growing industry; in the other, a prototype system is slowly taking hold in a handful of sites.

This paper is based on a presentation at a panel on Technology and Restructuring, Creating a Context for Learning and Evaluation, *at the meeting of the American Educational Research Association, Boston, MA, April 18, 1990.*

Systems Designed to Fit the Current Structure

Computer technology is not inherently inconsistent with current school structures. In the last few years, a product category has emerged that makes it quite easy for schools to acquire and use computer technology without major changes in their goals or organization. A report by the EPIE Institute (Sherry, 1990), an independent consumer information organization, provides a detailed catalogue of this class of school technology called integrated learning systems (ILS) or, more recently, integrated instructional systems (IIS). These systems typically consist of networked personal computers with a fileserver that both delivers programs to the individual workstations and keeps records on the progress of individual students. The ILS software (or courseware) covers most of the school curriculum—thus the term "integrated." Systems are sold to school districts at costs ranging from $60,000 to $180,000 for a "lab" of 20 to 30 stations. These systems are growing in popularity according to the EPIE report ,which estimates that sales doubled in 1989.

The EPIE report documents a generally high level of satisfaction with ILS systems among the teacher and student end users. The EPIE researchers also note that

> teachers want more software options, and (along with students) they want ILS lessons to be more varied and less repetitious in instructional style (or, as students put it 'less boring'). (p. 295).

Overwhelmingly, teachers say they would like to have the ILS stations in their own classrooms rather than in a lab so the work can be better integrated with their curriculum. In general, however, the ILSs can be considered a successful implementation of computers, one that serves a perceived need and fits well with the practices of the school. We can examine three prominent features of ILS use: location, curriculum, and the timeframe of the ILS tasks.

Location

The EPIE report notes that it is an all but universal practice to put the ILS in a lab. Although there is nothing inherent in the technology that requires this configuration, ILSs are sold as "labs" in units of about 30, which is sufficient to simultaneously accommodate a whole class. Having the ILS centralized in a lab means that the system can be more easily managed by a school computer lab teacher or a nonteaching paraprofessional. For a school starting with a low level of expertise, the centralization reduces the training costs that would otherwise be necessary. The vendors' sales representatives, often recruited from among retired school district superintendents, are expert at addressing management concerns in selling to the district administration (Resta, 1990).

As the use of these systems evolves over time, schools may begin distributing workstations among classrooms rather than centralizing them in a lab, in which case some of the prominent features of ILS practice may change (Mageau, 1990). The ratio of students to stations will change in the classroom favoring cooperative work. It also may become easier for teachers to integrate the activities into the rest of their instruction which, according to EPIE, is a common goal even in the centralized lab situation.

The 30 computers in a lab scenario assumes that students will be working at the computers individually, since it provides a one-to-one ratio. In many ILSs, students also wear headsets as part of their computer interactions, and thus are further removed from peer interaction. It is argued that the one-to-one instruction that is afforded by having students occupied with computer tutorials offers teachers an opportunity for individualized tutorial dialogue with students who are often ignored in whole-class teaching (Schofield, Evans-Rhodes, & Huber, 1990). This change may be considered a major restructuring of the teacher-student relationship. While this is a fundamental change from the traditional classroom lecture style, in many respects the change is easily accommodated to the curriculum goals, assessment techniques, and class scheduling already in place.

Curriculum

Another feature that provides a good fit to the organizational structure of the typical school is the content organization of the courseware. It is straightforward to categorize the courseware into the standard school subjects: math, reading, language arts, or science. This is no different from the typical textbook, which is designed to cover the material in a particular, recog-

nized subject area. In fact, ILSs are often tied explicitly to the major textbooks. Also, like the typical textbook, the content is, for the most part, presented as facts or procedures to be mastered in sequence. While several ILSs provide tools such as word processors and calculators, the presentation of the courseware is predominantly designed to match the sequence of topics in the textbooks.

The content and its sequencing is an integral part of the management and evaluation functions. Discrete tasks that result in a single correct answer can be evaluated by the system itself. More open-ended tasks requiring, for example, formulation of the problem or research into sources outside the computer or any kind of free-form response cannot be handled by the system. The arguments of the sales force usually focus on achievement gains, especially on standardized tests of basic skills for which the superintendents must answer to the school board and parent community, and which find their way into state and national reports of school achievement. These arguments are made in spite of the doubts expressed by reputable researchers about the validity of the ILS claims for achievement gains (Mageau, 1990). Often, state and federal funds that are targeted for disadvantaged students can be used directly for purchasing these systems because of the strong relation between the students identified for these special programs and low test scores.

The division of topics into clearly defined subject areas also eliminates the need for teachers handling different subjects to collaborate or for a teacher in a self-contained classroom to consider the integration of learning across the subjects. In this respect, too, ILSs strongly support the structure of most schools where teachers are not expected to know much about what other teachers are doing. A major advantage of ILSs, in comparison to other approaches to school technology, is that teachers and students can get started using the system with little technical or subject matter training and without adopting new styles of teaching or interacting with other teachers.

Timeframe

A common complaint of ILS users, according to the EPIE report, is that many systems will not pick up exactly where the student left off in the last session. Tasks are intended to be completed within the timeframe of a single period in the computer lab. Single tasks, such as an arithmetic problem, can usually be done in a matter of a few minutes, but, these short tasks may still overlap the end of a period and need to be picked up later. ILSs are designed on the assumption that each period will be self-contained. The tasks do not require preparation prior to the computer lab period and call for a minimum of technical capability on the part of the student. This design allows it to fit nicely into the usual school structure that is divided into periods devoted to discrete topics and, in the upper grades, taught by different teachers. Teachers can thus schedule the use of the computer lab into the preexisting slots in the day. The short tasks of the ILS are also very similar to the kinds of tasks found on the standardized tests. The short, carefully constrained answer slots are ideal for automatic scoring in both instances. The timeframe assumed by ILSs is thus well suited to the structure of the school day, which is broken down into discrete periods.

The Earth Lab Project

For the last four years, the Earth Lab project has been designing, implementing, and observing the effects of a local area network (LAN) system intended to facilitate collaborative work in elementary school earth science. Our plan was to create a prototype LAN system and demonstrate it in a New York City public school using an earth science curriculum. The pedagogical rationale was that students should use technology the way real scientists do: to communicate and share data; that is, to collaborate. The school is a public elementary school (grades 3 to 6) located in Central Harlem, New York City. The school population of approximately 700 students is predominantly African-American with a minority of Hispanic and other groups. The school's achievement scores are about average for New York City but lower than the national averages. With a few exceptions, the staff took a traditional approach to teaching through whole class lessons, textbook reading, and worksheet drill. Under normal circumstances, the school would have been a likely customer for an integrated learning system. However, in this case the school's computer teacher, who had a different vision, was able to play a leadership role and make use of the technology provided by the project.

Earth Lab supports restructuring through a decompartmentalization of instruction. In designing the environment, we assumed that students would benefit from seeing the connections among topics, such as between math and science or science and writing. Projects that groups of students undertake can be made more authentic and perhaps more motivating if related to real-world concerns where disciplinary boundaries do not necessarily hold. Students can also become more motivated if their school work is to a greater extent under their own control rather than tightly controlled by the school schedule. Classroom tasks may have to extend beyond the single lesson period, since once students begin working with some autonomy, the project may involve new goals that are discovered in the process. Teacher relationships, including distribution of expertise and collaboration among the teaching staff, may change as student projects begin to cross over the compartmentalized curriculum structure. Evaluation of students may also have to move from the typical short-answer tests of individuals to assessments of the group performance of the project itself.

A year-long formative experiment began in the fall of 1986. In the initial setup, a LAN connected the 25 Apple IIe computers in the school to a hard drive, which allowed for central storage of data, text, and programs. The Bank Street Writer word processing program was enhanced with an electronic mail system (Nerwman, 1990). The Bank Street Filer was another basic tool that made it possible for students to create databases that could be accessed from any computer in the school. Along with the technology, we introduced a year-long earth science curriculum designed in collaboration with the teachers (Brienne & Goldman, 1989). The formative experiment took as its goal an increase in the frequency of collaborative work among students. At least for the one year in which systematic research was funded, we were prepared to modify the design of the technology, introduce new software, develop curriculum materials, and conduct staff development workshops as needed (Newman, 1990). After the first year, the school obtained 20 additional Apple IIGS computers through an award from Apple Computer Inc. and over the last few years has added several other computers, including five Macintosh computers. Several other application programs are in use on the network, including "hypermedia" systems, LogoWriter, telecommunication programs, and Macintosh programs including desktop publishing tools.

Databases are used extensively both within and outside the the earth science curriculum. During the lunch hour, students are found inventing databases of their favorite action figures. In social studies, students research almanacs and other sources to fill in databases about countries of the world and figures from African-American history. In earth science, they examine databases of dinosaur fossils and earthquakes and create databases of weather readings and indicators of seasonal change that small groups of students collect over a period of several months.

The primary means for supporting collaborative groups is the Earth Lab's network interface, which makes it easy for individuals or groups to store and retrieve data pertaining to their projects. The work of the project, in the form of text, database, graphics, and code files, is stored in workspaces which are folders or directories on the network fileserver. These workspaces, available to any computer on the school LAN, give groups a location for their work together. Students and teachers can be assigned to any number of workspaces. For example, workspaces are set up for pairs of students to work on writing assignments together. Other workspaces serve schoolwide clubs or other projects. Each individual also has a personal workspace. In the first year of the project, the science teacher, who had the students for two periods a week, had the class form into groups of three or four for the purpose of conducting investigations in the science lab. The science groups gave themselves names that were used for group workspaces on the network. Students share different data with different students or groups in the school; for instance, a science group, a noon hour club, and the whole class. The current Earth Lab network system is designed to present the same information when students are on either Macintosh or Apple II computers.

When our project began, our explicit goal was to create a classroom environment in which students used technology the way scientists did: for collaborative work. Our analysis of what actually happened led us to a broader conception of how the local area network technology can function. While direct support of collaborative work groups is still important, we have increasingly become interested in the decompartmentalization of the school that can result from this kind of use of a local area network. Teachers are better able to collaborate, students are better able

to carry their work from one context to another, and the computer lab is increasingly used in a heterogeneous manner with several projects or groups from different classes working simultaneously. This restructuring supports both individual and group work and contributes to a sense of community in the school. The following examples taken from our observations at the school illustrate these changes within the same categories used to describe the integrated learning systems.

Location

From an initial 25 computers, the school's network has grown to about 50 in two separate labs—a satellite lab in a small room off one of the classrooms and network connections in several other classrooms into which computers can be moved as needed. When teachers bring their class to the lab, they stay with the class rather than hand it over to the computer teacher. The computer teacher works with the classroom teacher to develop activities that can be continued in class. The way the project workspaces were set up for groups and individuals helped to develop a sense of continuity not possible with ILSs. The following stories illustrate some of the ways this worked.

We expected that projects would be started while the class was in the computer lab and would be continued in the classroom. We found that students were taking this flexibility another step. For example, we observed two girls working on a book report at a computer in a small room off their classroom. They had not finished when the teacher announced it was time for the class to go upstairs to the computer lab. Instead of dropping their work, they brought their notes with them and asked if they could continue their work at a lab computer while the rest of the class worked on other assignments. The students logged on and called up the file on which they had been working. The network makes the boundaries between classrooms and class periods more permeable. This permeability was used by the students to pursue their tasks on their own initiative.

Several students from different classes and different grades were editors for the school newspaper. The newspaper had a workspace on the network that students used for storing articles and other material for the newspaper. Beyond the editorial group, many students around the school contributed articles to the newspaper by sending them as messages through the electronic mail system to the editors. The common workspace made it easy for the editorial group to work at different times and places on the newspaper. The ease with which any student could contribute to the newspaper and the identity of the group task that was supported by the workspace widened participation. Students became familiar with the network's function as a data organizer so that when other school projects, such as editing a video newscast, were started, students thought it quite sensible to create a workspace for their scripts, plans, and edit lists.

Although the computer labs, housed in adjacent rooms, have enough computers to accommodate a class with a one-to-one ratio, we seldom see the computers used that way. Usually students work in pairs or small groups. Since there are spare computers, students from other classrooms which do not have their own computers and teachers on their prep periods also come to the lab to work on various projects. As a result, activities in the labs are very heterogeneous.

Students frequently work in groups and very often work with more than one computer simultaneously. For example, a group of students was using the Bank Street Writer to compose a letter to students in Australia with whom they had been telecommunicating. One of their members suggested that they include some of the data from their math project in the report. A second student turned to an unused computer at the next desk. She called up the Bank Street Filer, compiled the report and "printed" it to the group workspace on the network, converting it into a word processing file where it was easily merged into the letter they were preparing. When the letter was finished, it was mailed on the LAN to the person responsible for portaging it to Australia. It was possible for the students to create a "multitasking system" out of the two computers because they knew in terms of the workspace where one computer had to save the data in order for the other computer to find it. For the students who were accustomed to sharing data on the network, it was quite obvious how to do it.

The fact that the "tool" applications (as opposed to games or drills, i.e., content-specific programs) were used heavily made group and individual projects the appropriate mode of computer use. The Earth Lab interface, which displays for students and teachers lists of their project workspaces, enables them to work on any of their projects whenever they have the opportunity and inclination at any of the networked ma-

chines available to them. With this greater continuity over space and time, students can take greater initiative in following through with work on a project.

Curriculum

The earth science curriculum developed for the initial field test and the curriculum materials that the teachers have continued to develop over subsequent years have been interdisciplinary. As they worked on weather and seasonal change, students made connections to physics, math, writing, and social studies. The network system made classroom projects easier to manage and promoted collaboration among the teachers.

Over the initial year of observations, there was substantial movement from whole-class teaching toward more collaborative work in small groups. We found that the science groups which had been formed to work together in the science lab were being used by the classroom teachers for a variety of social studies research activities, some of which were unrelated to the earth science curriculum. The network system produced these changes in an unexpected way: It made it possible for all teachers to assign classroom work to the groups created by the science teacher. The science group workspaces were a convenient means for organizing small-group projects in other curriculum areas. The science groups became a resource across the school. There had never been a mechanism by which a social organizational structure created by one teacher in this school could be used by other teachers as a resource for managing instruction (Newman, Goldman, Brienne, Jackson, & Magzamen, 1989).

At the beginning of the field-test year some teachers in this essentially traditional school had doubts about the students' capabilities for handling the autonomy involved in small-group work. Having the small group workspaces on the network helped communicate to the teacher community that students were expected to do collaborative work. Where interdisciplinary projects become a more common feature of the curriculum, the workspaces can give the students a clearer group identity or sense of project continuity and thus help in the classroom management. Instead of greater centralized control of individualized instruction, as is common in integrated learning systems, control can be distributed to the students. We suspect that the solution to the teachers' difficulties in managing instruction involving collaboration among the students is to provide students with tools with which they can assume some of the burden, rather than to provide teachers with tools with which to gain greater control.

But students are not simply going off on their own projects unconnected to any curriculum goals of the teachers. The network also makes it easier for the teachers to appropriate the output of the small groups into whole-class activities so as to go back and forth between individual or group work and integrative projects that combine the work of the small groups. The LAN technology seemed naturally to invite coordination in which students contribute to some larger quest for knowledge since it was easier to give common access to the same shared database than to maintain separate copies for each individual or group (Newman, et al.). An example is provided by our weather data-collection project. The data had been collected by a rotating group of students throughout the school year from a small rooftop weather station and entered into a database in a shared weather folder. The database was later used to discover correlations between such variables as pressure and cloudiness. The whole dataset became the object of group discussions of relationships that cannot be found in the individual contributions. This coordination around a shared database was a new activity structure that emerged with the LAN technology.

The Earth Lab network made no attempt to provide a technological solution to the problem of assessing student progress or grading student projects, which is the central function of integrated learning systems afforded by the hierarchical nature of the courseware. We have, however, begun exploring the use of group and individual workspaces as portfolios of student work. The notion of a portfolio is receiving growing attention among educators as an alternative means of assessment in which the stages of work on a project collected in a portfolio can provide insight into both the teacher and the student about the state of their work and, in retrospect about the process of learning (Gardner, in press). The workspaces currently serve as archives of the group or individual project work and so, in this sense, can serve the function of a portfolio.

Timeframe

The project workspaces provide continuity over time as well as location. Projects involving collecting

weather data and data on seasonal change extended over many months. In some cases, projects may extend over years as new cohorts of students move through the school curriculum. The continuity over time that is developing in the school may have an important impact on what students are able to do as they gain technical skills with the computer tools available for their project work. The following examples suggest the nature of that impact.

One science group was analyzing the weather data using the Bank Street Filer database manager. They were trying to support a theory suggested by their impression that the last winter had been much milder than the previous one. They were comparing their data with those collected by last year's sixth grade class. When their theory was not supported by averages in the report generated with the Filer program, one of the students checked the data entered by their classmates. Several temperatures seemed unrealistic; for example, several January days with highs of zero degrees. Suspecting an error attributable to missing values, they sent electronic messages to representatives of several other classes who had kept similar records and obtained actual data for the days in question.

Many students used the system extensively for their own work in addition to the work assigned as part of instruction. Much of the student-initiated work occurred during lunch and after school when the computer lab remained open. Students were able to pursue their own writing, data-collection, or programming projects. While some educational games were also available during these extra periods, many students chose to pursue projects rather than to play games. Students developed a sense of ownership of their workspaces to a greater extent than we anticipated, and some students accumulated hundreds of files in their workspaces over the course of a year. Earth Lab was also used for student-initiated collaborative work; for example, on science fair projects, which were a source of great pride for many groups of students. Their appropriation of the technology also was evident in end-of-the-year interviews. For example, one student suggested enabling students to determine who could have access to a workspace because she did not have easy access to work she was doing with another student. Her suggestion was based on a need that arose in her own attempts at collaboration. Taking her suggestion one step further, our more recent implementation has made it easy for students to create their own workspaces as well as to determine who would be able to use the files in the workspace.

The use of tool software requires a greater initial investment in order to bring students up to speed with the technology than is required for integrated learning systems, which present small tasks and simple interactions with the technology. However, the availability of the Earth Lab system to students over a period of years and the consistency of the available tools has made it increasingly easy for teachers to introduce long-term projects as part of their curriculum. In the first year of operation, the sixth grade class spent several months on fairly simple introductory projects designed to familiarize them with the word-processing, database, and communication tools. Several years later, teachers were able to start immediately with substantial projects. Although students enter sixth grade with widely varying levels of expertise due to the uneven use of the technology among the fifth grade teachers, enough students have the necessary expertise to support the start up of projects. In one case, the class began early in the year to collect data on the length of their shadows. Students who were familiar with the Filer entered all the data into a database, which was then available for all the students to explore. So students who were unfamiliar with the tool were introduced to it in the context of substantial data that they had helped to collect.

The school in which Earth Lab has been operating for four years is now engaged in a major restructuring involving the creation of a school-within-the-school that will focus on an experiment in teacher collaboration. Approximately one fifth of the students have voluntarily signed up for a "Computer Mini-School," which will involve six classrooms spanning the grades three through six. The classrooms, four of which bridge between grades, will be heterogeneous with respect to achievement levels. Each year, new students will be recruited for the third grade slots, and the program is expected to slowly expand horizontally to additional classes per grade. There is no shortage of volunteers spanning the range of achievement levels found in the school. A portion of the school's computer technology will serve this Mini-School, which will continue to take advantage of the technology in the ways that have been illustrated. The choice of forming the mini-school from a sequence of grades is important for developing continuity over a long period and building the skills

and expectations among both the students and teachers. It is expected that the sixth grade teachers will be continually challenged by the growing skills of their incoming classes.

Summary

Common to these observations is the perception that students had a place in the computer system, namely, their individual and group workspaces containing their project data that was not dependent on having an individual computer or being in a particular classroom. Both students and teachers made use of the workspaces to bridge between school contexts. The extent to which both teachers and students appropriated the system into their own work gives us reason to believe that systems like Earth Lab are sustainable in the educational environment. The system that we installed in the school was to some extent modelled on the use of technology in research labs, but the system that emerged had characteristics quite specific to schools; for example, the coordination of small groups, the teacher collaboration, and the use of workspaces rather than personal workstations. Our formative experiment succeeded in using technology to increase the likelihood of collaborative work groups, but we also discovered that a critical function of LAN technology in schools is to make a more seamless connection between school contexts. In this respect, we found ourselves focusing more on the level of the school organization and the collaboration among teachers than on the level of the students working collaboratively around a computer.

Conclusion

This paper has contrasted two very different uses of local area network technology in schools attempting to trace their relationship to the way the school organizes instruction, the way teachers work together, and the opportunities students have for engaging in long-term, open-ended projects. The relationship between technology and the organization of instruction is complex. An integrated learning system certainly does not cause schools to have a compartmentalized curriculum sequence and division of labor among teachers. It may, however, provide strong support for those tendencies and place barriers in the way of teachers who may wish to change their mode of instruction. At the same time, the use of these systems can be modified quite radically by, for example, distributing the computers among the classrooms where they might become more integrated with the ongoing classroom work. In the same way, a system like Earth Lab does not cause collaborative, interdisciplinary project work to happen. But for schools that are moving in that direction, it can provide some useful tools and mechanisms.

In planning a replication of the Earth Lab environment in other schools, we face the complex relationship between the technology system and the existing structure of instruction in the new schools. Typically when schools acquire technology, the approach is to purchase a new "lab," even when the technology is to be devoted to word processing or programming or earth science projects. The lab becomes the convenient unit for administering the new computers and for conceptualizing the need when arguing for it to the administrators who will make the decision. In developing the materials for the replication of Earth Lab, we were encouraged to think in terms of a technology/curriculum package that could be implemented in a lab that was devoted to science instruction at a particular grade level. Distribution of the computers around the school could not be part of the package and it was unreasonable to think in terms of developing an integrated curriculum. From a purely administrative point of view, the people in charge of technology acquisition often have no authority over school structure, so they necessarily appropriate the technology to the existing school structure. The restructuring that the Computer Mini-School is engaged in cannot be provided to the school in the usual technology/curriculum "package." The flexibility of location and time, the collaboratively constructed interdisciplinary curriculum, and the provision for student access to the tools over an extended period are critical components of this environment. The design of a local area network system like Earth Lab, however, can help in slowly subverting a rigid structure by supporting teachers and students in developing and propagating the innovation.

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References

Brienne, D., & Goldman, S.V. (1989, April). Networking: How it has enhanced science classes in New York schools . . . and how it can enhance classes in your school too. *Classroom Computer Learning*, 44-53.

Carnegie Forum on Education and the Economy. (1986). *A nation prepared: Teachers for the 21st century*. New York: Carnegie Corporation of New York.

Cohen, D. K. (1988). Educational technology and school organization. In R. S. Nickerson & P. Zodhiates (Eds.), *Technology and education: Looking toward 2020*. Hillsdale, NJ: Erlbaum.

Collins, A. (in press). The role of computer technology in restructuring schools. In K. Sheingold & M. Tucker (Eds.), *Restructuring for learning with technology*.

Cuban, L. (1986). *Teachers and machines*. New York: Teachers College Press.

Gardner, H. (in press). Assessment in context: The alternative to standardized testing. In B. R. Gifford & M. C. O'Connor (Eds.), *Future assessments: Changing views of aptitude, achievement and instruction*. Boston: Kluwer.

Mageau, T. (1990). ILS: Its new role in schools. *Electronic Learning*, *10*(1), 22-32.

Newman, D. (1990). Cognitive and technical issues in the design of educational computer networking. In L. Harasim (Ed.), Online education: Perspectives on a new medium. New York: Praeger.

Newman, D. (1990). Opportunities for research on the organizational impact of school computers. *Educational Researcher*, *19*(3), 8-13.

Newman, D., Goldman, S. V., Brienne, D., Jackson, I., & Magzamen, S. (1989). Peer collaboration in computer-mediated science investigations. *Journal of Educational Computing Research*, *5*(2), 151-166.

Resta, P. (1990). Factors to consider in selecting and purchasing integrated instructional systems. In M. Sherry (Ed.), *The integrated instructional systems report*. Water Mill, NY: EPIE Institute.

Schofield, J., Evans-Rhodes, D., & Huber, B. R. (1990). Artificial intelligence in the classroom: The impact of a computer-based tutor on teachers and students. *Social Science Computer Review*, *8*(1).

Sherry, M. (Ed.). (1990). *The integrated instructional systems report*. Water Mill, NY: EPIE Institute.

Sizer, T. R. (1984). *Horace's compromise*. Boston: Houghton-Mifflin.